STRONTIUM

A. Commodity Summary

According to the U.S. Bureau of Mines, no strontium minerals have been produced in the United States since 1959. The United States is however, a major producer of strontium compounds. In 1994, primary strontium compounds were used in color television picture tube glass (66%), pyrotechnic materials (11%), ferrite ceramic magnets (13%), and other miscellaneous uses (10%)[1]. Although consumption demands fluctuate from year to year, the overall consumption of strontium compounds and metals appears to be increasing.[2]

In early 1984, Chemical Products Corporation (CPC) in Cartersville, Georgia expanded its capacity by 30% to meet shortfalls in supply that resulted from the 1984 closure of the FMC Corporation plant in Modesto, California. CPC is now the sole domestic producer of strontium carbonate and strontium nitrate; CPC sells these products as raw materials to other industries.[3] Strontium metal is produced by CALSTRON near Memphis, Tennessee using an aluminothermic reaction.

B. Generalized Process Description

1. Discussion of Typical Production Processes

Celestite, the most common strontium mineral, consists primarily of strontium sulfate. The second most common strontium mineral, strontianite, consists primarily of strontium carbonate.

Reportedly, it is very difficult to concentrate strontium minerals to grades acceptable for producing chemical compounds. The two most common celestite-to-strontium carbonate conversion processes are the soda ash process and the calcining process. Strontium metal is produced by (1) the thermal reduction of strontium oxide with metallic aluminum and (2) the electrolysis of fused strontium chloride and ammonium or potassium chloride.

Of the two strontium production processes, the soda ash method is a simpler process; however, the resulting product is of a lower grade. The calcining method or black ash method, produces chemical-grade strontium carbonate ($SrCO_3$) which is at least 98% strontium carbonate; whereas, the soda ash method only produces technical-grade strontium carbonate $\geq$95% pure. Although the soda ash method is a simpler process, the lower grade product causes it to be the less preferred method of recovery. The black ash method is used by CPC.

2. Generalized Process Flow Diagram

<u>Strontium Carbonate Process</u>

Soda Ash Process

Finely powdered celestite is mixed with soda ash and treated with steam for one to three hours. The celestite and soda ash react to produce less soluble strontium carbonate and soluble sodium sulfate. The two are separated by centrifuging. Exhibit 1 presents a process flow diagram for the soda ash process.

Calcining Process (Black Ash Process)

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[1] Joyce Ober, "Strontium," from <u>Mineral Commodity Summaries</u>, U.S. Bureau of Mines, January 1995, pp. 164-165.

[2] Joyce A. Ober, "Strontium," <u>Minerals Yearbook Volume 1. Metals and Minerals</u>, U.S. Bureau of Mines, 1992, pp. 1323-1332.

[3] Personal communication between ICF Incorporated and Joyce Ober, Bureau of Mines, July 21, 1994.

Finely powdered coal is mixed with celestite which produces a "black ash." The mixture is heated to 1,100°C in a rotary kiln, expelling oxygen in the form of carbon dioxide from the insoluble strontium sulfate to form water-soluble strontium sulfide. The strontium sulfide is dissolved in water and the solution is filtered, and then either treated with carbon dioxide or soda ash in an agitation tank. Strontium carbonate may then form and precipitate from the solution. The strontium carbonate precipitate is removed from solution by filtering in vacuum drum filters, dried, ground, and packaged. The sulfur released in the process is either recovered as elemental sulfur or as other by-product sulfur compounds. This process is used by the CPC plant in Georgia but is called the "white ash method" because the sodium sulfide is white in color.[4] A process flow diagram is shown in Exhibit 1.

Production of Strontium Chemicals

Strontium nitrate is produced by reacting strontium carbonate with nitric acid. Other strontium chemicals are produced similarly by reacting strontium carbonate with the acid appropriate for the desired result.

Production of Other Strontium Compounds

Chemical-grade strontium carbonate can be used without further purification to produce most other strontium compounds. Either chemical-grade or technical-grade (greater than 95% pure) can be used for transformation to other strontium compounds, and in the conversion processes further purification occurs. For some processes, higher grades of strontium carbonate are necessary and elimination of contamination by particular elements is emphasized.

Strontium Metal Production

Strontium metal can be produced in two ways. The more common method is through the thermal reduction of strontium oxide and aluminum metal, subsequent distillation and condensation of metallic strontium on a cooled plate. The other method is electrolysis of a fused bath of strontium chloride and ammonium chloride or potassium chloride.[5]

[4] "Strontium--Uses, Supply, and Technology," U.S. Bureau of Mines Information Circular, 1989, p. 6.

[5] Ibid.

EXHIBIT 1

SIMPLIFIED FLOWCHART OF TWO METHODS FOR STRONTIUM CARBONATE PRODUCTION

Graphic Not Available.

Source: 1988 Final Draft Summary Report of Mineral Industry Processing Wastes, 1988, pp.3-198 - 3-199.

Other Processes

Strontium ferrite magnets are usually prepared by mixing strontium carbonate, iron oxide, and crystal growth inhibitors and presintering at 1,000°C to 1,300°C. Strontium titanate is formed by reacting a mixture of high purity strontium carbonate and titanium dioxide at 2,000° to 2,200°C for several hours.[6]

3. Identification/Discussion of Novel (or otherwise distinct) Process(es)

Technologically, there is very little known about strontium. As technology becomes more sophisticated and the search for alternate materials is intensified, specific properties of strontium will become better known. Strontium appears to have applications in the metallurgy of aluminum, silicon, and other light metals, as well as potential use as a solid electrolyte in fuel cells.[7]

A new process for the extraction and recovery of strontium from acidic waste streams is being developed. In this process, SREX (Strontium Extraction), strontium is extracted from acidic solution and is stripped from the organic phase using either water or dilute HNO_3. Prolonged exposure of the process solvent to nitric acid at elevated temperatures or to radiation from a ^{60}CO source produces essentially no deterioration in its performance. Experiments show that 99.7% of the strontium initially present in a feed solution can be removed using only three extraction stages.[8]

4. Beneficiation/Processing Boundaries

Based on a review of the process, there are no mineral processing operations involved in the production of strontium.

C. Process Waste Streams

1. Extraction/Beneficiation Wastes

Black Ash Method

Calciner offgas. Calciner emissions may contain carbon dioxide which may or may not be recycled into the agitation tank. This offgas may also contain sulfur dioxide and ore particles.[9]

Dilute sodium sulfide solution.

Filter muds.

Spent ore.

Vacuum drum filtrate.

Waste solution.

Soda Ash Method

Waste sodium sulfate solutions.

2. Mineral Processing Wastes

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[6] Ibid.

[7] John E. Ferrell, "Strontium," from Mineral Facts and Problems, U.S. Bureau of Mines, 1985, pp.777-782.

[8] Philip E. Horowitz, Mark L. Dietz, and Dan E. Fisher, "SREX: A New Process for the Extraction and Recovery of Strontium from Acidic Nuclear Waste Streams," Argonne National Laboratory, 1991, pg. 1.

[9] U.S. Environmental Protection Agency, "Strontium," from 1988 Final Draft Summary Report of Mineral Industry Processing Wastes, 1988, pp. 3-198 - 3-203.

None identified.

D. Ancillary Hazardous Wastes

Ancillary hazardous wastes may be generated at on-site laboratories, and may include used chemicals and liquid samples. Other hazardous wastes may include spent solvents (e.g., petroleum naptha), acidic tank cleaning wastes, and polychlorinated biphenyls from electrical transformers and capacitors.

Bibliography

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